

Q1. Which one of the equations below represents a reaction that is feasible at all temperatures?

- A $P(s) \rightarrow Q(s) + R(g)$ endothermic
- B $2L(g) + M(g) \rightarrow 2N(g)$ exothermic
- C $S(g) \rightarrow 2T(g)$ exothermic
- D $A(g) + B(g) \rightarrow C(g)$ endothermic

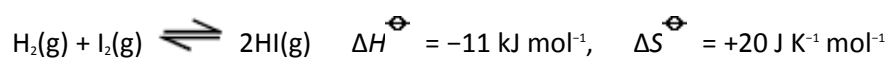
(Total 1 mark)

Q2. Which one of the following reactions in aqueous solution has the most positive change in entropy?

- A $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$
- B $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$
- C $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + \text{EDTA}^{4-} \rightarrow [\text{Cu}(\text{EDTA})]^{2-} + 6\text{H}_2\text{O}$
- D $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Cu}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$

(Total 1 mark)

Q3. Refer to the following reaction



Which one of the following statements is correct?

- A This is a redox reaction.
- B The reaction is **not** feasible below 298 K
- C At equilibrium, the yield of hydrogen iodide is changed by increasing the pressure.
- D At equilibrium, the yield of hydrogen iodide increases as the temperature is increased.

(Total 1 mark)

Q4. This question is about the reaction given below.



Enthalpy data for the reacting species are given in the table below.

Substance	CO(g)	H ₂ O(g)	CO ₂ (g)	H ₂ (g)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-110	-242	-394	0

Which one of the following statements is **not** correct?

- A The value of K_p changes when the temperature changes.
- B The activation energy decreases when the temperature is increased.
- C The entropy change is more positive when the water is liquid rather than gaseous.
- D The enthalpy change is more positive when the water is liquid rather than gaseous.

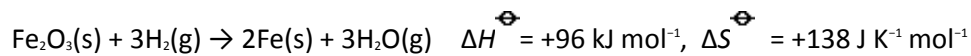
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Q5. Which one of the following statements is **not** correct?

- A The first ionisation energy of iron is greater than its second ionisation energy.
- B The magnitude of the lattice enthalpy of magnesium oxide is greater than that of barium oxide.
- C The oxidation state of iron in $[\text{Fe}(\text{CN})_6]^{3-}$ is greater than the oxidation state of copper in $[\text{CuCl}_2]^-$.
- D The boiling point of C_3H_8 is lower than that of $\text{CH}_3\text{CH}_2\text{OH}$.

(Total 1 mark)

Q6. Using the information below, answer this question.



	Fe₂O₃(s)	H₂(g)	Fe(s)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-822.0	0	0
$\Delta S^\ominus / \text{J K}^{-1} \text{ mol}^{-1}$	90.0	131.0	27.0

The standard entropy value for steam is

- A +332 J K^{mol}⁻¹
- B +189 J K^{mol}⁻¹
- C +145 J K^{mol}⁻¹
- D +85 J K^{mol}⁻¹

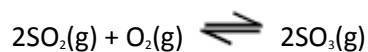
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Q7. In which one of the following reactions is there a decrease in entropy?

- A $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) + 3\text{C}_2\text{O}_4^{2-}(\text{aq}) \rightarrow [\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$
- B $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + \text{EDTA}^{4-}(\text{aq}) \rightarrow [\text{Cu}(\text{EDTA})]^{2-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$
- C $[\text{CoCl}_4]^{2-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow [\text{Co}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + 4\text{Cl}^-(\text{aq})$
- D $\text{Na}_2\text{CO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow 2\text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

(Total 1 mark)

Q8. This question relates to the equilibrium gas-phase synthesis of sulphur trioxide:



Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
$\text{SO}_3(\text{g})$	-396	+257
$\text{SO}_2(\text{g})$	-297	+248
$\text{O}_2(\text{g})$	0	+204

This equilibrium, at a temperature of 585 K and a total pressure of 540 kPa, occurs in a vessel of volume 1.80 dm^3 . At equilibrium, the vessel contains 0.0500 mol of $\text{SO}_2(\text{g})$, 0.0800 mol of $\text{O}_2(\text{g})$ and 0.0700 mol of $\text{SO}_3(\text{g})$.

The standard entropy change for this reaction is

- A $-222 \text{ J K}^{-1} \text{mol}^{-1}$
- B $-195 \text{ J K}^{-1} \text{mol}^{-1}$
- C $-186 \text{ J K}^{-1} \text{mol}^{-1}$
- D $+198 \text{ J K}^{-1} \text{mol}^{-1}$

(Total 1 mark)

Q9. Which one of the following best explains why the lattice enthalpy of magnesium chloride is much larger than that of lithium chloride?

- A Magnesium has a greater electronegativity than lithium.
- B Magnesium ions have a greater polarising power than lithium ions.
- C Magnesium ions have a greater ionic radius than lithium ions.
- D Magnesium ions have a greater charge than lithium ions.

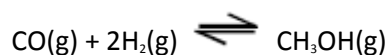
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Q10. Which one of the following has the most covalent character?

- A MgF₂
- B MgBr₂
- C AlF₃
- D AlBr₃

(Total 1 mark)

Q11. The following information concerns the equilibrium gas-phase synthesis of methanol.



At equilibrium, when the temperature is 68 °C, the total pressure is 1.70 MPa.
The number of moles of CO, H₂ and CH₃OH present are 0.160, 0.320 and 0.180, respectively.

Thermodynamic data are given below.

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
CO(g)	-110	198
H ₂ (g)	0	131
CH ₃ OH(g)	-201	240

The standard entropy change for this reaction is

- A -220 J K⁻¹ mol⁻¹
- B +220 J K⁻¹ mol⁻¹
- C -89 J K⁻¹ mol⁻¹
- D +89 J K⁻¹ mol⁻¹

(Total 1 mark)

Q12.The compound lithium tetrahydridoaluminate(III), LiAlH_4 , is a useful reducing agent. It behaves in a similar fashion to NaBH_4 . Carbonyl compounds and carboxylic acids are reduced to alcohols. However, LiAlH_4 also reduces water in a violent reaction so that it must be used in an organic solvent.

Which one of the following concerning the violent reaction between LiAlH_4 and water is **false**?

- A A gas is produced.
- B The activation energy for the reaction is relatively high.
- C The reaction has a negative free-energy change.
- D Aqueous lithium ions are formed.

(Total 1 mark)

Q13.Which one of the following has the most covalent character?

- A MgF_2
- B MgBr_2
- C AlF_3
- D AlBr_3

(Total 1 mark)